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ABSTRACT

Presented are instructions for the use of "RATS," a model simulating the dynamics of a rat population in either a city or an apartment house. The student controls the conditions of growth and sets the points at which the computer program prints reports. The rat population is controlled by variables including garbage levels selected for the site, and types and quantity of poison applied. At the end of the simulation, the program prints details on the nature of the rat population, the dollar value of damage done by the rats, cost of poison, and amount of poison left uneaten. (Author/RE)

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Huntington II Simulation Program – RATS

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STUDENT MANUAL

RATS

CONTROL OF RAT POPULATION

MARIE RULON

HUNTINGTON TWO COMPUTER PROJECT

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RATS

STUDENT MANUAL

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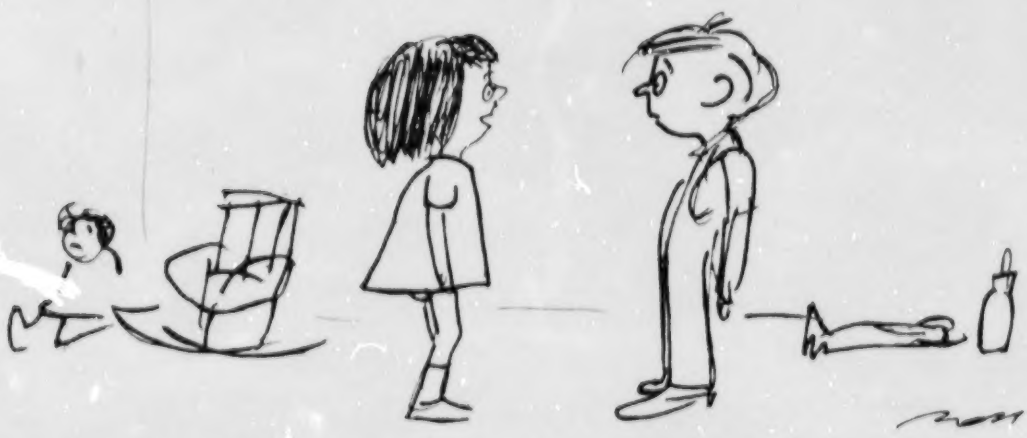

"What kind of house shall we play; upper class, middle class or rat-infested?"

Ross - Rothco Cartoons 3131-2

I. DESCRIPTION OF THE *RATS* SIMULATION

A public health commercial on a metropolitan TV station shows a young child playing in a crib in a run-down apartment. A rat scurries across the floor. The child calls, "Here kitty, kitty, kitty."

The child's mistake horrifies the viewer, and one cannot help but take a minute out of their TV watching to think about the necessity of rat control. Because rats carry disease and thrive on garbage, good sanitation is a must in populated urban areas. But if garbage is uncollected, rats can multiply. When the condition grows serious, health departments may take steps to clean up an area and use the technology they have available to eliminate rats.

In this simulation you are similar to a health department official devising an effective, practical plan to eliminate a rat problem. You will specify and vary a rat-control plan for a whole city or for an apartment house. The amount of rats that can exist in your simulation is dependent on the garbage level, or the sanitary condition of the area. If there is a large amount of food available along with many nesting sites for the rats, then the garbage level would be 10, indicating the poorest sanitation possible. A garbage level of 0 would indicate the best sanitation possible. (See *RESOURCE MANUAL* for illustrative examples, pp. 9-10.)

When the sanitary conditions in the city are at their worst, the city can support 1 million rats. The apartment house can support a maximum of 200 rats. In this model, the apartment house has 4 stories and a basement, with 4 apartments on each floor. The rats are distributed 8 to each apartment, 8 to each hallway, and 40 in the basement.

As you run the program *RATS*, you select

- whether you want the simulation to take place in a city or an apartment building
- whether you want a daily report of the number of rats in the area
- the number of rats that initially are existing in the area being studied
- the date for each summary report
- the garbage level
- the type and quantity of poison you may wish to use in a control program.

In addition to being able to control the initial number of rats in a run and the garbage level, you may also specify a particular poison and the amount of that poison to be used. You may also leave the poison out, pick it up, or add additional poison. The computer will tell you what kind of poison may be specified: (1) a quick-kill poison which is 60% effective within the first day, and (2) a slow-kill poison which takes 3 to 10 days of feeding to begin to be effective.

II. DESCRIPTION OF THE *RATS* PROGRAM

The *RATS* computer program simulates the growth pattern of a rat population and prints a report at the end of a specified period of time. The user controls the conditions of growth and specifies the time of report.

The program will print a daily count of the rat population for any specified period of time. This daily status is affected by the garbage level specified for the environment and by the type and quantity of poison which may be spread.

At the end of the specified period, a report is printed showing the total population and the distribution of the population by age in months, the number of births and deaths, and the count of emigration and immigration. Upon termination of the run, a report is produced which lists the accumulated births, deaths, emigrations and immigrations for the entire run, the dollar value of the damage done by the rats, the contamination level produced by the rats, the type and amount of rat poison uneaten and the cost of rat poison.

A. Running the Program

At the beginning of the simulation, the computer asks the user to respond to the following questions:

▷ WHICH ENVIRONMENT IS THE SIMULATION TO BE CONDUCTED IN (1=APARTMENT HOUSE, 2=CITY)?

▷ DO YOU WISH (1=YES, Ø=NO)

▷ AUTOMATIC INITIALIZATION OF POPULATION?

If the response to this question is "NO", the computer then asks:

▷ HOW MANY RATS ARE PRESENT?

▷ DAILY POPULATION STATUS?

▷ MONTH, DAY FOR REPORT?

▷ GARBAGE LEVEL UNTIL (MONTH/DAY)?

▷ TYPE OF POISON (Ø=NONE, 1=QUICK KILL, 2=SLOW KILL)?

If the response to this question is QUICK KILL or SLOW KILL, the computer asks:

▷ QUANTITY OF POISON (LBS)?

When these questions are answered, the computer prints out the table specified. Then it asks:

▷DO YOU WISH TO CONTINUE THIS RUN (1=YES, Ø=NO)?

A "YES" answer takes you back to previous question (DO YOU WISH DAILY POPULATION STATUS?) for a continuation of the run. The second time through the program, you are given another option on your poison: TYPE OF POISON (Ø=NONE, 1=QUICK KILL, 2=SLOW KILL, 3=LEAVE CURRENT POISON). If you select Ø, all the old bait is picked up. If you select 1 or 2, it adds your new amount of poison to the old amount still left uneaten by the rats. If you select 3, no new poison is added; however, the old bait is left in the area. Any time you switch from one type of poison to another, the computer prints out that the first type of poison was picked up when the new poison was placed out. A "NO" answer will cause the computer to print out the final report with totals or final results and then stops execution of the program.

B. Definition of Terms

- *DAILY POPULATION STATUS* - refers to the number of rats on each day. This printout shows the day and the number of rats. At the beginning of each month, it also shows the month and the number of rats before day 1 begins.

- *CARRYING CAPACITY* - refers to the maximum number of rats that can exist in the specified environment. This number is controlled primarily by the food and the harborage (nesting sites) available. The carrying capacity for an area may be exceeded by up to 20% for a short period of time.

- *GARBAGE LEVEL* - refers to the sanitation in an area and is rated on a scale from Ø to 1Ø. A garbage level of 1Ø is the worst condition you may encounter and a level of Ø is the cleanest. (See *RESOURCE MANUAL*, pp.9 and 10 for illustrative examples.) The carrying capacity at a garbage level of 1Ø is 200 rats for the apartment building and one million rats for the city in this simulation. The garbage level includes both the food and harborage available to the rat. Each rat needs a minimum of 3 ounces of food per day to survive and reproduce.

POISONS: QUICK KILL and SLOW KILL - refer to the two main types of poisons that are used in rat contro. The success of either type of rodenticide (rat poison) depends on the amount of other food available for the rodent (rat) as stated by the garbage level. All rodenticides used in this simulation are 10 times more palatable than the food the rat normally eats. In a real-life situation this also true, but the poison must be easily accessible to the rats.

"Quick kill" poison immediately kills any rat that eats it. The efficiency of this type of poison drops to zero after the first kill because the remaining rats refuse to eat any when they see the corpse by the poison. If not used again for six months, its efficiency increases 10% per month until it returns to its 60% efficiency.

"Slow kill" poison will eliminate all of the rodent population if no other food is available. It takes 3 to 10 consecutive feedings before death occurs. A rat will eat a slow kill poison more than once because there is no evidence that it is poisonous. Rats will eat only once a day. In this simulation, the number of days of feeding before death occurs is selected randomly for the one- and two-month-old rats. An additional day is added to kill the three- and four-month-old rats, and another day is required for the five- and six-month-old rats. The older the rat, the more poison needed to cause death. Also, the number of rats that eat a poison depends on the ratio of non-poisonous to poisonous food available.

- *CONTAMINATION LEVEL* - refers to the amount of contamination by all of the rats over the period of time of the entire run. Rats contaminate by urinating, defecating and by shedding hair. The greater the average number of rats during a period of time, the greater the contamination level.

- *EMIGRATION* - refers to excess rats leaving an area.

- *IMMIGRATION* - refers to new rats moving in from adjacent areas.

III. NOTES ON RUNNING THE PROGRAM

During the running of the program, all questions must be answered with a number. Thus, when asked a yes/no question, you enter "1" for "YES" and "Ø" for "NO". For example, if you wanted the number of rats each day to be printed, you would answer "1" (for "YES") to the question "DAILY POPULATION STATUS?".

Another yes/no question is "AUTOMATIC INITIALIZATION OF POPULATION?" If you answer "1" (for YES), the computer will set the number of rats at approximately the maximum level for the environment you have specified. If you answer "Ø" for "NO", the computer will then ask you "HOW MANY RATS ARE PRESENT?"

The question "MONTH, DAY FOR REPORT?" is asking you to enter the date on which you want the next summary report. The dates always start with the first month and day (1,1). Remember, this question is always asking for the *date* and not the number of days and months.

Another question which is not self-explanatory is "GARBAGE LEVEL UNTIL 1/23?", which asks you to specify the garbage level until 1/23. The garbage level is on a scale from Ø to 1Ø, with 1Ø being the worst condition and Ø being the best condition.

After each summary report, the computer will ask "DO YOU WISH TO CONTINUE THIS RUN?" This is a yes/no question and and should be answered with either a "1" or a "Ø".

IV. COMPUTER LABORATORY MANUAL

A. Investigating the Population Growth Rate

1) Run the *RATS* simulation program specifying the environment to be conducted in an apartment house.

   a) Start with 35 rats; get a daily printout until the 15th day of the first month (enter 1,15 in response to "MONTH, DAY FOR REPORT?); specify a garbage level of 8 and do not specify any poison.

   b) Continue the run with a daily printout until the 30th day of the first month (1,3Ø) and a garbage level of 8 and no poison.

When you have completed this run, look back over the number of rats for each day. Does the growth rate appear to be uniform? _____

Would you expect the population growth to continue increasing for another month until it reached between 300 to 400 rats?

_____

What factor(s) that are reported cause the population growth to increase?

_____

Which factor(s) cause the population growth to decrease?

_____

Make a graph of the population growth for the entire month. Use the graph paper provided in the back of the *STUDENT MANUAL*. (Keep your printout for later reference.)

2) Run the *RATS* program again for an apartment building.

a) Start with 35 rats; do not get a daily printout, but get a summary report on the 30th day of the first month (1,30); specify the garbage level at 8 and do not specify any poison.

b) Continue the run with a daily printout until the 15th day of the second month (2,15). Specify the garbage level at 8 and no poison.

c) Continue the run with a daily printout until the 30th day of the second month (2,30). Specify the garbage level at 8 and no poison.

d) Compare the results you obtained in the summary report on 1/30 with the final results on 1/30 of the run in Part 1 above.

Was the total population about the same? _____

Did any of the following vary between two runs by the end of the first month:

Births? _____ Emigration? _____

Deaths? _____ Immigration? _____

What happened to the population growth rate during the second month?

_____

_____

_____

e) Using both runs, fill in this table:

Date	Births	Deaths	Emigration	Immigration
1,15	_____	_____	_____	_____
1,30	_____	_____	_____	_____
2,15	_____	_____	_____	_____
2,30	_____	_____	_____	_____

What would you conclude happens when the population becomes greater than an area can support?

_____

_____

_____

_____

How many rats are up to 1-month old at the end of the second month? P(1) = _____

What conclusion can you make about this difference?

_____

_____

_____

_____

f) Compare the number of 5-month and 6-month-old rats at the end of the first month's run with the 5- and 6-month-old rats on 2/15.

What do you think is the approximate life span of rats? _____

3) Run the *RATS* program for a city starting with 100000 rats. Specify a daily printout and a summary report every 30 days for 2 months. Maintain a garbage level of 8 and use no poison.

Make a graph of the population growth for the first month.

What happens to the population growth during the second month?

_____

_____

_____

Would you expect the growth rate to continue during the third month as it did during the second month or would you expect it to be like the first month?

_____

_____

Explain why

_____

_____

_____

B. Investigating the Effectiveness of the Quick-Kill Poison

Most often when a person wishes to rid an area of rats, he thinks of poison which will do the job quickly. A quick-kill poison is the obvious selection.

1) What is the effect of a quick-kill poison?

a) Use a quick kill poison for 5 days in a city with a garbage level of 1. Start with 50000 rats, administering 1 pound of poison per rat (3 oz. per day). Ask for a daily population status.

b) Continue run for second 5-day period leaving the current amount of quick-kill poison present in the area. Keep the garbage level at 1.

c) Calculate the death rate for each period by dividing the number of rats at the beginning of each period into the number of deaths during that period. For

example, if initially there are 50000 rats and 25000 were killed, the death rate would be:

$$\frac{25000}{50000} = 0.5$$

What is the death rate for the first 5 days?_____

What is the death rate for the second 5 days? _____

What conclusion can you draw because of this difference?

_____

_____

_____

_____

_____

2) What if fresh poison were put out every day?

a) Make a new run using quick kill poison in a city with a garbage level of 1, initially occupied by 50000 rats, administer 1 pound of poison per rat for 1 day.

b) Continue the run for a second day administering an additional 50000 pounds of fresh poison. Keep the garbage level at 1. The old poison in the area (not eaten) will continue to be present.

c) Continue the run also for a third, a fourth and a fifth day, each time administering an additional 50000 pounds of fresh quick kill poison. Keep the garbage level at 1. Each time the old poison in the area (not eaten) will continue to be present.

d) Calculate the death rate for each day $\left[\frac{\text{Number of rats died that day}}{\text{Total rats originally present that day}}\right]$

Day	Death Rate
1	_____
2	_____
3	_____
4	_____
5	_____

Now what conclusion can you draw because of these differences?

e) Why are some rats dying even though the poison is not eaten?

f) Compare this death rate with the rate obtained over the five days in Part 1 above. Which method for administering the quick-kill poison achieves the best kill rate?

Which method do you think would cost the least?

3) How much quick-kill poison is needed to be effective without costing too much? (This would be called the optimum amount.)

a) Run the *RATS* program using a "ladder" of values for the amount of poison. The number of rats killed for each amount of poison used is the result you want. Use these values in your run:

- a city with a garbage level of 1
- initial rat population of 50000
- run for one day without the daily population status report
- specify the quick-kill poison at these levels for your first "ladder":

Pounds Poison	Number of Rats Killed	Quantity of Unused Poison
75000	_____	_____
50000	_____	_____
25000	_____	_____
15000	_____	_____
10000	_____	_____
5000	_____	_____
2500	_____	_____

b) On regular graph paper, plot the number of rats killed against the pounds of poison spread. Examine the curve you have on the graph paper; pick a value where the curve begins to break away. This is a rough approximation of the optimum quantity of quick-kill poison to use.

At 50000 to 75000 pounds of poison you have the most kills, but do you have very many more than were killed by the dosage of 25000 pounds?

Also you can see that, from 10000 pounds on down, the number of deaths decreases markedly.

This says that the optimum amount of poison to use is somewhere around 15000 to 25000 pounds, and one choice is as good as another without going into complex calculations.

c) Now find the optimum amount of quick-kill poison to use for a garbage level of 5 in a city. Specify the initial rat population at one half of the carrying capacity for the specified environment. (This equals 250000 rats.)

C. Investigating the Effectiveness of the Slow-Kill Poison

The slow-kill poison is so named because repeated feedings are needed to cause death. Death may occur from 3 to 10 days after the poison is spread. In addition, as the rats get older, more feedings are needed.

The *RATS* program simulates real life by randomly selecting the first day on which death is to occur. As a result every run is different as kill rates vary. The amount of poison needed, however, can be figured approximately for any run.

Rats are known to feed once daily and need at least 3 ounces of food to exist and reproduce. Thus, in 5 days each rat eats about 1 pound of food.

Kill-rate curves can be developed which will allow you to predict with some accuracy the population remaining alive on any day, and the best day for spreading new amounts of poison.

1) Start by running the *RATS* program as follows:

   - a city with a garbage level of 1
   - initial rat population of 50000
   - run for 30 days with the daily population status printed
   - specify the slow-kill poison at a rate of 1 pound per rat for every 5 days of the run. For the first 30 days this would require 300000 pounds of poison (6 x 50000)

2) Rerun the program several more times leaving the garbage level at 1, the initial rat population at 50000. Each time run for 30 days. Use the following amounts of slow-kill poison: 250000, 500000, 1000000 lbs. and 50000 lbs. of bait.

3) On regular graph paper, plot the number of rats reported as living on each day against the number of days.

   From any one of these curves, can you determine the day on which the population can be expected to reach its low point?

4) Why, with even 1000000 pounds of bait, do you not eliminate the rats? Is simply placing out more and more poison the best answer to rodent control?

5) What happens to the rodent population during the first 10 days and during the last two weeks of the month when all of the slow-kill poison is gone? (Examine your last run using 50000 lbs. of poison.)

D. Investigating the Effect Cleaning Up an Area Has on the Rat Population

The carrying capacity for an area depends on the garbage level in that area. Cleaning up the area will reduce the carrying capacity and, in this series of runs, you will try to determine what becomes of the rats in an area of reduced carrying capacity.

This time make one run using a "ladder" of garbage level values; run each level for 15 days using these specifications:

- a city where the computer specifies the initial population of rats
- run at each level for 15 days with a daily population status printed
- specify that no poison is to be used
- start with a garbage level of 10. After 15 days, reduce to a level of 8; then, after each 15-day period, reduce the garbage level by 2. When 0 garbage level is reached, keep repeating the run at this level every 15 days until a zero population is reached.

At the end of the first run of 15 days and at a garbage level of 10, add the number of rats that were born to the initial number of rats.

number of rats initially _____

births _____

sum _____

How does this compare with the number of rats reported on day 15?

_____

How do you account for the difference?

_____

_____

_____

_____

Does the same result hold true for all other garbage-level values?

Approximate how many days at a new garbage level were necessary to reach a state of equilibrium?

How many days at a garbage level of Ø were needed to reduce the rat population to zero?

E. Devising a Plan for Eliminating Rats

Using the information you have developed on quick-kill poison, slow-kill poison and reduction of the garbage level, write a plan for cleaning up a city that has a garbage level of 1Ø. Remember that clean-up of garbage in an area takes considerable time.

After you have completed your plan, run the *RATS* program and try it out. If problems develop, modify your plan and make necessary adjustments in the run. Try to get rid of the rodents in the least time possible without any of them emigrating from the area.

What is a reasonable time to clean up one building? How about one city block? Or, how about your borough or precinct? In some cities, groups have gotten together to clean up their neighborhoods; try to find out how long it took and what level of cleanliness they achieved. Also, from newspaper accounts, you may be able to determine the types of poisons used and the application schedule.

F. Follow-Up Questions

From your experiences with the *RATS* program and from reading the *RESOURCE MANUAL*, you should be able to answer the following questions.

1) Why does the number of rats in a given area exceed the maximum carrying capacity?

2) What happens to the excess rodents?

3) What factors limit a rat population?

4) If an existing rodent population is less than an area can support, what happens?

5) What factors determine how fast a rodent population increases?

6) How realistic is it to have a sanitation level of Ø?

7) a) What happens if you have a high rodent population, drop the sanitation level and fail to use a rodenticide?

b) Why is this condition dangerous?

8) How does the sanitation level affect the maximum number of rats an area supports?

9) Is rodent control using only rodenticides effective? Why?

10) What problems are created by the increase in rat numbers?

11) Is continued rodent control necessary? Why?

12) Why was the poison less effective when there was more garbage around?

13) Of what value is it to have a detailed report of the rodent population before proceeding with your control program?

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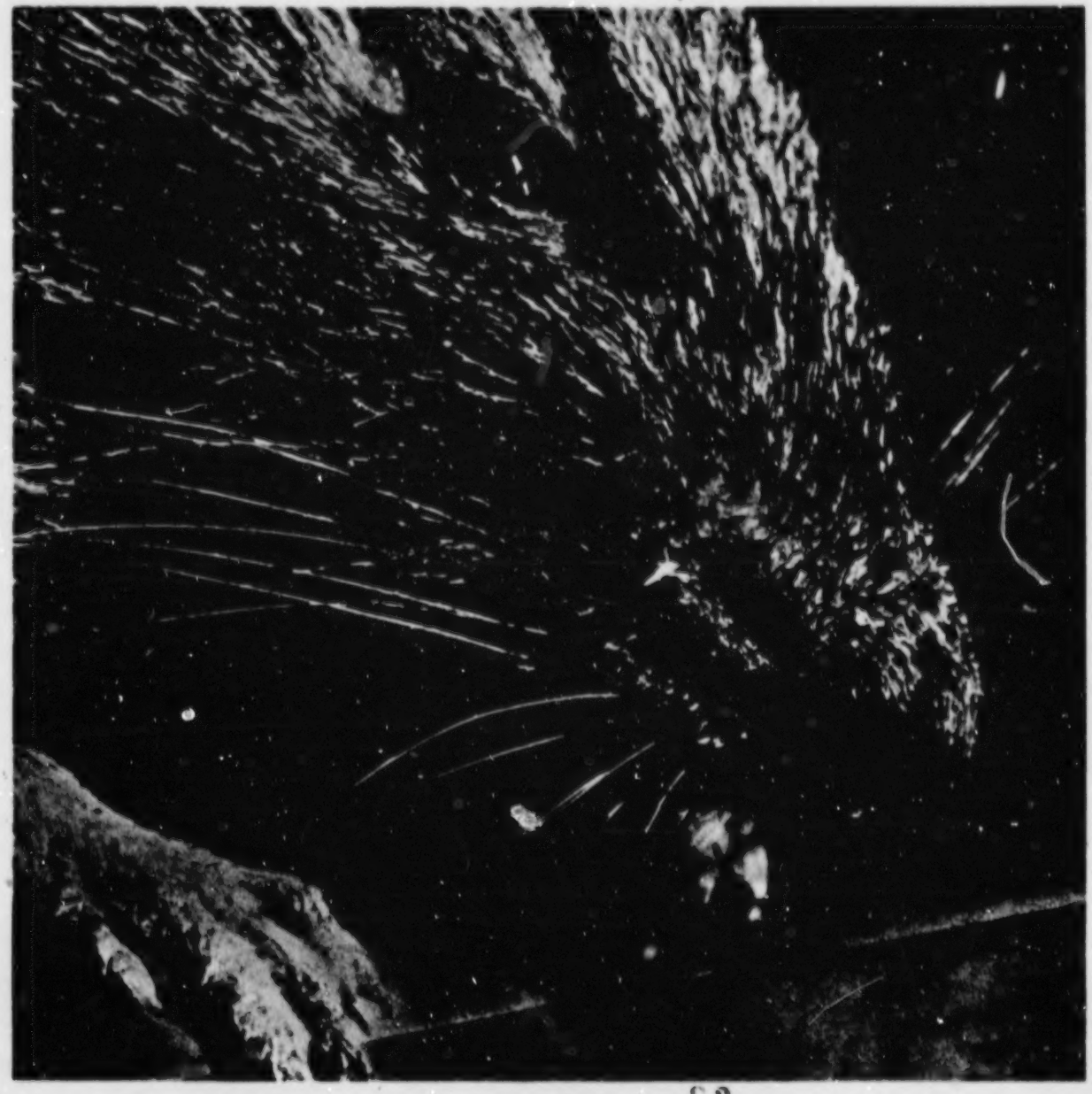

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RATS

CONTROL OF RAT POPULATION

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HUNTINGTON TWO COMPUTER PROJECT

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RATS

TEACHER MANUAL

I. BASIC INFORMATION ABOUT THE UNIT

Subject Area: Biology, Advanced Science, and Statistics

Specific Topic: Population Biology

Grade Level: 10th - 12th

Coordinated Computer Program: *RATS*

Computer Language: BASIC

Abstract: A computer simulation of the rat population in either a city or an apartment house with the environment and population control techniques entered by the student.

II. DESCRIPTION OF THE *RATS* UNIT

This unit is composed of three parts: the *TEACHER MANUAL* which you are reading, a *STUDENT MANUAL*, and a *RESOURCE MANUAL*. The student is expected to use both the *RESOURCE MANUAL* and the *STUDENT MANUAL* in his work on this subject.

The *STUDENT MANUAL* provides a description of the experiment and the computer program. Key words are defined and special notes on running the program are included. It also serves as a laboratory manual which describes the experiments to be performed and aids the student in interpreting the data collected. In performing the experiments, the student investigates the population growth rate, the effectiveness of quick-kill and slow-kill poisons, the effect of cleaning up an area, and finally the student devises and tests an overall plan for eradication and control of rats.

The *RESOURCE MANUAL* gives background information which was used in developing the model. Charts, illustrations, projects, and the assumptions that underlie *RATS* are included for the student to read.

III. DESCRIPTION OF THE *RATS* PROGRAM

RATS simulates the growth pattern of a rat population and prints a report at the end of a specified period of time. The user controls the conditions of growth and sets the time of report.

The program will print a daily count of the rat population for any specified period of time. This daily status is affected by the garbage level selected for the environment and by the type and quantity of poison which may be spread.

At the end of the specified period, a report is printed showing the total population and the distribution of the population by age in months, the number of births and deaths, and the count of emigration and immigration. Upon termination of the run, a report is produced which lists the accumulated births, deaths, emigrations and immigrations for the entire run, the dollar value of the damage done by the rats, the contamination level produced by the rats, the cost of rat poison and the amount and type of poison left uneaten.

A. Running the Program

At the beginning of the simulation, the computer asks the user to respond to the following questions:

```
▷ WHICH ENVIRONMENT IS THE SIMULATION TO
  BE CONDUCTED IN (1=APARTMENT HOUSE, 2=CITY)?
```

▷ DO YOU WISH (1=YES, Ø=NO)

▷ AUTOMATIC INITIALIZATION OF POPULATION?

If the response to this question is "NO", the computer then asks:

▷ HOW MANY RATS ARE PRESENT?

▷ DAILY POPULATION STATUS?

▷ MONTH, DAY FOR REPORT?

▷ GARBAGE LEVEL UNTIL (MONTH/DAY)?

▷ TYPE OF POISON (Ø=NONE, 1=QUICK KILL, 2=SLOW KILL)?

If the response to this question is QUICK KILL or SLOW KILL, the computer asks:

▷ QUANTITY OF POISON (LBS)?

When these questions are answered, the computer prints out the table specified. Then it asks:

▷ DO YOU WISH TO CONTINUE THIS RUN (1=YES, Ø=NO)?

A "YES" answer takes you back to previous question (DO YOU WISH DAILY POPULATION STATUS?) for a continuation of the run. The second time through the program, you are given another option on your poison: TYPE OF POISON (Ø=NONE, 1=QUICK KILL, 2=SLOW KILL, 3=LEAVE CURRENT POISON). If you select 1 or 2, it adds your new amount of poison to the old amount still left uneaten by the rats. If you select 3, no new poison is added; however, the old bait is left in the area. Any time you switch from one type of poison to another, the computer prints out that the first type of poison was picked up when the new poison was placed out. A "NO" answer will cause the computer to print out the final report with totals or final results and then stops execution of the program.

B. Definition of Terms

- *DAILY POPULATION STATUS* - refers to the number of rats present each day. This printout types the day and the number of rats. At the beginning of each month, it also shows the month and the number of rats before Day 1 begins.

- *CARRYING CAPACITY* - refers to the maximum number of rats that can exist in the specified environment. This number is controlled primarily by the food and the harborage (nesting sites) available. The carrying capacity for an area may be exceeded by up to 20% for a short period of time.

- *GARBAGE LEVEL* - refers to the sanitation in an area and is rated on a scale from Ø to 1Ø. A garbage level of 1Ø is the worst condition you may encounter and a level of Ø is the cleanest. (See *RESOURCE MANUAL*, pp. 9 and 10 for illustrative examples.) The carrying capacity at a garbage level of 1Ø is 200 rats for the apartment building and one million rats for the city in this simulation. The garbage level includes both the food and harborage available to the rat. Each rat needs a minimum of 3 ounces of food per day to survive and reproduce.

- *POISONS: QUICK-KILL and SLOW-KILL* - refer to the two main types of poisons that are used in rat control. The success of either type of rodenticide (rat poison) depends on the amount of other food available for the rodent (rat) as stated by the garbage level. All rodenticides used in this simulation are 10 times more palatable than the food the rat normally eats. In a real-life situation this is also true, but the poison must be easily accessible to the rats.

  "Quick-kill" poison immediately kills any rat that eats it. The efficiency of this type of poison drops to zero after the first kill because the remaining rats refuse to eat any when they see the corpse by the poison. If not used again for six months, its efficiency increases 10% per month until it returns to its 60% efficiency.

  "Slow-kill" poison will eliminate all of the rodent population if no other food is available. It takes 3 to 10 consecutive feedings before death occurs. A rat will eat a slow-kill poison more than once because there is no evidence that it is poisonous. Rats will eat only once a day. In this simulation, the number of days of feeding before death occurs is selected randomly for the 1- and 2-month-old rats. An additional day is added to kill the 3- and 4- month-old rats, and another day is required for the 5- and 6-month-old rats. The older the rat, the more poison needed to cause death. Also, the number of rats that eat a poison depends on the ratio of non-poisonous to poisonous food available.

- *CONTAMINATION LEVEL* - refers to the amount of contamination by all of the rats over the period of time of the entire run. Rats contaminate by urinating, defecating and by shedding hair. The greater the average number of rats during a period of time, the greater the contamination level.

- *EMIGRATION* - refers to excess rats leaving an area.

- *IMMIGRATION* - refers to new rats moving in from adjacent areas.

IV. NOTES ON RUNNING THE PROGRAM

Before running the program, the user will need to determine the following information:

- Whether the environment in which the simulation is to be conducted is an apartment building or the entire city.

- Whether you want the computer to automatically initialize the rat population, that is, to set the number of rats in the environment; or whether you want to set the level of rat population, in which case you must also provide the number.

- Whether you want a daily report on the status of the rat population.

- The date on which you want a summary report of the rat population; on this summary report day you may also enter new environmental conditions. The date is always entered as month first and then day. Each month is assumed to have only 30 days. The numbering of the months always begins at 1 from the start of the running of the program. In this way, if you wanted your first report after two months you would enter 2,30 in response to the question "MONTH, DAY FOR REPORT?".

- The garbage level is to be set for the area to be studied on a scale of 0 to 10. A garbage level of 10 is the worst you can have, while a level of 0 is as sanitary as possible.

- The type and quantity of poison to be used for rat control may be specified. By responding with "0", no poison is to be used and any old poison in the area is removed. A "1" is entered to specify a quick-kill poison; "2" is entered to specify a slow-kill poison; and a "3" is entered to indicate that no new bait is added. The old bait is left in the area. The quantity to be used must be entered in pounds.

On the following pages of this section, the sample runs of RATS included are intended to be indicative of the output format and the degree of flexibility available in the program. The runs also provide a check when the program is first entered into the computer to ensure proper operation. Keep in mind that the program incorporates several random factors which create slight variations in results from one run to the next. You will note that in each run the total population is also broken down so that P(1) represents the total number of 1-month-old rats, P(2) the total number of 2-month-old rats, and so forth for all rats aged 1 month to 6 months.

V. SAMPLE RUNS OF *RATS*

RUN 1

```
            RATTUS NORVEGICUS POPULATION SIMULATION

WHICH ENVIRONMENT IS THE SIMULATION TO
BE CONDUCTED IN (1=APT HOUSE, 2=CITY) ?2

DO YOU WISH (1=YES, 0=NO) :

        AUTOMATIC INITIALIZATION OF POPULATION ?0
        HOW MANY RATS ARE PRESENT ?50000

        DAILY POPULATION STATUS ?0

MONTH, DAY FOR REPORT ?3,9

GARBAGE LEVEL UNTIL 3 / 9  ?3

TYPE OF POISON (0=NONE,1=QUICK KILL,2=SLOW KILL) ?0

            ***** MONTH 1 *****
            TOTAL POP.= 50000

            ***** MONTH 2 *****
            TOTAL POP.= 233402

            ***** MONTH 3 *****
            TOTAL POP.= 310896

REPORT ON 3 / 9 :
TOTAL POPULATION= 317848

P( 1 )= 9976        P( 2 )= 86385       P( 3 )= 195620
P( 4 )= 8616        P( 5 )= 10207       P( 6 )= 7035

BIRTHS= 372843                  DEATHS= 66647
EMIGRATION= 44593               IMMIGRATION= 6245

DO YOU WISH TO CONTINUE THIS RUN ?0

FOR THIS RUN:
        449703. DOLLARS OF DAMAGE DUE TO RATS
        PRODUCING A CONTAMINATION LEVEL OF 3
```

RUN 2

```
WHICH ENVIRONMENT IS THE SIMULATION TO
BE CONDUCTED IN (1=APT HOUSE, 2=CITY) ?1

DO YOU WISH (1=YES, 0=NO) :

        AUTOMATIC INITIALIZATION OF POPULATION ?1

        DAILY POPULATION STATUS ?1

MONTH, DAY FOR REPORT ?1,15

GARBAGE LEVEL UNTIL 1 / 15  ?3
BASED ON A GARBAGE LEVEL OF 3 IN ENVIRONMENT 1
THE RAT POPULATION INITIALLY IS 60

TYPE OF POISON (0=NONE,1=QUICK KILL,2=SLOW KILL) ?2
QUANTITY OF # 2 POISON (LBS) ?60


DAY             RATS
---             ----

              ***** MONTH 1 *****
              TOTAL POP.= 60

 1               65
 2               69
 3               72
 4               41
 5               23
 6               8
 7               5
 8               5
 9               6
 10              7
 11              8
 12              9
 13              10
 14              11
 15              12

REPORT ON 1 / 15 :
TOTAL POPULATION= 12

P( 1 )= 11          P( 2 )= 0          P( 3 )= 0
P( 4 )= 0           P( 5 )= 1          P( 6 )= 0

BIRTHS= 30                        DEATHS= 87
EMIGRATION= 0                     IMMIGRATION= 0

DO YOU WISH TO CONTINUE THIS RUN ?0


FOR THIS RUN:
        QUANTITY OF UNUSED POISON TYPE 2 IS 0
        COST OF POISON IS 26.4 DOLLARS
        11.17 DOLLARS OF DAMAGE DUE TO RATS
        PRODUCING A CONTAMINATION LEVEL OF 1
```

VI. WHY WAS THIS UNIT DEVELOPED?

Man has been plagued by rats ever since he moved into dwellings: a cave, a lean-to or an ivory tower. The problem of rat control and eradication exists not only in the city and town but also on the farm and ranch.

Many methods have been used to control the rat population, but no one method has been found to be satisfactory by itself. The *RATS* simulation allows the student to experiment with different approaches to the problem and to determine the effectiveness of each method by itself or in combination with the others; then to devise a plan and test it. The computer program has built-in random factors which simulate the real-life conditions that any plan may meet. This provides the student with the normal variations of life and requires him to use the knowledge gained in his experimentation to adjust the treatment for greatest effectiveness without exceeding optimum costs.

The ability to study the effectiveness of various treatments in real-life situations is hampered by time and the vast resources that would be needed in the actual conditions. A plan that has been devised and tested by students in a group could be put into action in their own locale.

VII. WHAT CAN STUDENTS LEARN BY USING THE *RATS* UNIT?

Upon completion of this unit on rat control, the students should be able to:

- Describe the effect of slow-kill and quick-kill poisons on a rat population including the degree of effectiveness, the time-lag before death, the quantities needed for total effectiveness and proper sequencing for deployment of each.
- Describe the effect of the area garbage level on the rat population including what occurs when the population level is above or below the carrying capacity.
- Describe the relationship between the rat population, the contamination level and the damage in dollars.
- Describe the most effective means for rat elimination or control.
- List the reasons for multiple runs and multiple sampling when performing experiments.
- Describe a method by which a result can be obtained that approximates an average condition in an experiment (for example, obtaining the minimum quantity of slow-kill poison needed in a city with a garbage level of 1 and starting with 50000 rats).

To aid the student in achieving these goals, a series of follow-up questions is located in the *STUDENT MANUAL*, pages 15-16. Those questions are repeated here and answers included.

1) WHY DOES THE NUMBER OF RATS IN A GIVEN AREA EXCEED THE MAXIMUM CARRYING CAPACITY?

OFFSPRING KEEP SHOWING UP.

2) WHAT HAPPENS TO THE EXCESS RODENTS?

EXCESS RODENTS DIE OR LEAVE WITHIN A VERY SHORT TIME.

3) WHAT FACTORS LIMIT A RAT POPULATION?

THE AMOUNT OF WATER, FOOD, HARBORAGE AVAILABLE LIMIT RAT POPULATION.

4) IF AN EXISTING RODENT POPULATION IS LESS THAN AN AREA CAN SUPPORT, WHAT HAPPENS?

THE VOID IS QUICKLY FILLED WITH NEWBORN AND IMMIGRATING RODENTS.

5) WHAT FACTORS DETERMINE HOW FAST A RODENT POPULATION INCREASES?

SANITATION LEVEL, AGE OF PRESENT RATS AND IMMIGRATION RATE DETERMINE HOW FAST A RODENT POPULATION INCREASES.

6) HOW REALISTIC IS IT TO HAVE A SANITATION LEVEL OF Ø?

THIS IS ALMOST IMPOSSIBLE.

7) a) WHAT HAPPENS IF YOU HAVE A HIGH RODENT POPULATION, DROP THE SANITATION LEVEL AND FAIL TO USE A RODENTICIDE?

MANY OF THE RATS EMIGRATE OUT OF THE IMMEDIATE AREA INTO SURROUNDING AREAS.

b) WHY IS THIS CONDITION DANGEROUS?

IT SPREADS RODENTS TO OTHER AREAS AND MAKES EVENTUAL CONTROL MORE DIFFICULT.

8) HOW DOES THE SANITATION LEVEL AFFECT THE MAXIMUM NUMBER OF RATS AN AREA SUPPORTS?

THE WORSE THE SANITATION, THE MORE RATS YOU HAVE.

9) IS RODENT CONTROL USING ONLY RODENTICIDES EFFECTIVE? WHY?

NO. YOU MUST CLEAN UP TO AVOID BUILD-UP OF NEW RATS.

10) WHAT PROBLEMS ARE CREATED BY THE INCREASE IN RAT NUMBERS?

RODENTS CARRY DISEASE ORGANISMS AND PARASITES TO HUMANS. THEY ALSO DAMAGE PROPERTY BY CHEWING. THEY CONTAMINATE FOOD BY URINATING AND LEAVING HAIRS AND FECAL DROPPINGS.

11) IS CONTINUED RODENT CONTROL NECESSARY? WHY?

YES. NEW RATS MIGRATE INTO THE AREA.

12) WHY WAS THE POISON LESS EFFECTIVE WHEN THERE WAS MORE GARBAGE AROUND?

THE RATS FEED ON THE GARBAGE INSTEAD OF THE POISON.

13) OF WHAT VALUE IS IT TO HAVE A DETAILED REPORT OF THE RODENT POPULATION BEFORE PROCEEDING WITH YOUR CONTROL PROGRAM?

IT HELPS DETERMINE HOW MANY OFFSPRING ARE ANTICIPATED WITHIN THE NEXT 30 DAYS.

Summary of What the Student Should Learn from the Exercises Outlined in the *STUDENT MANUAL*

A. Investigating the Population Growth Rate

Exercise 1 - Rats will increase gradually until they reach maximum carrying capacity. Prior to reaching carrying capacity, new rats migrate into the area. Normal births and deaths continue to occur inside the area under investigation.

Exercise 2 - A prolonged period with constant environmental conditions results in a constant rodent population. The number of offspring depends not only on environmental conditions, but the age and number of rats capable of reproducing.

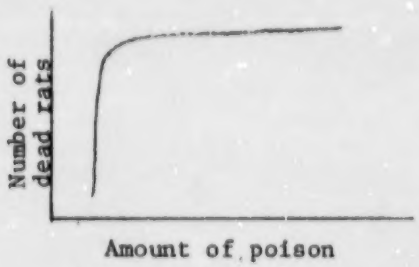
Exercise 3 - The growth rate of a rodent population in a city is similar to the growth rate in an apartment house.

B. Investigating the Effectiveness of the Quick-Kill Poison

Exercise 1 - Quick-kill poisons are effective once. Thereafter, the rats do not eat the poison.

Exercise 2 - Quick-kill poisons are effective for only one day. Thereafter, the rats do not eat the poison.

Exercise 3 - There is an optimum amount of quick-kill poison to use. It is dependent upon the garbage level of the area and on the number of rats in the area. The graph called for, plots as follows:



C. Investigating the Effectiveness of the Slow-Kill Poison

It takes 3 to 10 days for slow-kill poison to start taking effect. Without cleaning up the garbage, the efficiency of the rat poison does not increase significantly by simply putting out more poison.

D. Investigating the Effect Cleaning Up an Area Has on the Rat Population

Sanitation is the key to effective reductions of rodent populations.

E. Devising a Plan for Eliminating Rats

The best plan calls for:

a) putting out a quick-kill poison for 1 day (3 ounces of bait per rat)

b) cleaning up the area and, at the same time, putting out enough slow-kill poison so that there is at least 1 pound per rat. Continue to put bait out for as long as you run the program, especially if the garbage level is greater than Ø.

The idea is to eliminate the rats without having them migrate out into the surrounding area. To maintain a "rat-free" city, sanitation must be excellent.

VIII. HOW CAN THIS UNIT BE USED IN THE CURRICULUM?

The teacher using the *RATS* program in class need not have a strong math or statistical background, knowledge of rat life cycles, or the chemistry of poisons used. Most biology teachers have sufficient background in the principles involved to have a successful learning environment by following these suggestions:

A. Preparatory Activities for Use of the Unit

- Students should all be able to use the computer terminal to run the *RATS* program.
- Students will need to know how to graph data on regular graph paper.
- Students should study the *RESOURCE MANUAL* before starting any of the experiments. They should also be encouraged to refer freely to the *RESOURCE MANUAL* at any time during the experiment.
- If you, the teacher, are so inclined, you may wish to provide some exercises in statistical data reduction and interpretation and in statistical design of experiments and sampling.

B. Use of the Program

The *STUDENT MANUAL* calls for a number of runs of *RATS* to be conducted for each investigation. As a result, it is suggested that teams of students be assigned to make each of the basic investigations of the effectiveness of quick-kill poison, slow-kill poison and [illegible]-level decreases. These teams will report the values which result from their runs. Each individual in the class would be expected to make his own calculations, draw graphs, and interpret the data.

Each team would then draft its own plan for eradication and control of rats and run the program using their plan. The results obtained by the teams could be compiled and compared to determine the most effective approach and alternative approaches which might need to be considered in a real-life test.

In advanced science, chemistry and statistics classes, this unit may be used to study design of experiments, statistical treatment and interpretation of data, and to study dynamic and linear programming techniques.

C. Follow-Up Activities

1) Invite an outside speaker, who has been responsible for a clean-up and eradication program, to discuss the control plan that was used. Discuss where it failed or had to be modified as well as where it succeeded. Find out the cost of the project, the amount of involvement required from residents, any cost breakdowns that could be made, original budgets, excess fund or budget overruns, and reasons for each.

   In addition, the speaker should be asked to explain any plan that exists for continuation of the rat-control program, amount budgeted, etc.

2) Based on this further information and study, the students could develop their own project in the surrounding area or become involved in any on-going project nearby. A field trip to a project in progress to discuss plans, costs, achievements, anticipated achievements, and future programs would be valuable in studying the problem of rat-control firsthand.

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RESOURCE MANUAL

RATS

CONTROL OF RAT POPULATION

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HUNTINGTON TWO COMPUTER PROJECT

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RATS

RESOURCE MANUAL

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RATS

RESOURCE MANUAL

I. BACKGROUND INFORMATION

The following pages contain information on the Norway rat (*Rattus Norvegicus*), which is the rat used in this model.

Page 9 has a drawing of an area showing a very high garbage level. When you get to that page, try to find all of the rats pictured. On page 10 the same area shows a garbage level of zero. On page 10 in the right-hand corner, you are told the total number of rats pictured on page 8. See if you can find them all.

THE NORWAY RAT*

Rattus Norvegicus (Berkenhout) = Latin Name

What does it look like?

Adult Norway rats are 16 to 19 inches long, including a 7 to 7½-inch tail. The tail is semi-naked and conspicuously ringed. It has a blunt nose and close-set ears. A young rat has large feet in proportion to its body. See identification chart on page 7 for differentiation among Norway and roof rats and house mice. Norway rats are usually grayish-brown in color, but may vary from a pure gray to a blackish or reddish brown.

How large does a Norway rat get?

Norway rats rarely go over 1 pound and more often, when fully grown weigh 12 ounces. Stories told of rats 5 to 50 pounds are just that, stories. It is reported that the largest rat ever recorded weighed 44 ounces.

Are there other names for this rat?

The brown rat, house rat, wharf rat, sewer rat, barn rat, water rat and gray rat are the same. They are all Norway rats. The white albino laboratory rat is a specially bred Norway rat.

What is its life cycle?

Female adult Norway rats usually are ready to mate when they are about 4 months old, but some mate at age 2½ months. A single female mates and carries her young for about 35 days before giving birth to 2 to 22 young, with an average of 8 to 10 young. The newborn young are naked and blind. After 2 weeks they open their eyes, but continue to feed from the female for another 2 weeks. Female rats have 3 to 6 litters per year. The number of young per litter and the number of litters per year depend upon the amount of food available, temperature, age and condition of the female. Norway rats can live 6 to 12 months in nature. In captivity, they may survive for 3 years or longer. In the wild, a Norway rat living for one year is the exception, rather than the rule.

Where is it found?

Norway rats are found wherever man lives, as well as in the wild. These animals are burrowing creatures and most of their lives live in the ground. Once inside a structure, they seek secluded dark areas, but can be found from the basement to the attic.

THE NORWAY RAT by Dr. Austin Frishman, p.2-6; © 1971 by Copesan Services, Inc., (reproduced with permission).

What does it eat?

These rats feed on a wide variety of foods, but prefer meats, grain, grain products, cooked eggs and fresh fruits. They usually dislike raw beets, peaches, onions, cauliflower and spiced food. They eat 1 ounce of dry material per day, but destroy much more than they eat. Rats are most active at night and usually feed at this time, unless there is a shortage of food.

Must rats have water?

Unlike mice, rats must have liquids to survive. Rats can lap water from a puddle or a dripping faucet. They can obtain their fluids from moist foods. Rats can, on occasion, obtain enough water from the dew on grass or even tapping the fluid flowing through the roots of a living shrub.

Do rats live in colonies?

It is true that rats live in colonies. If a stray rat were to wander into another rat colony's territory, it would be attacked and chased off. Within each colony there is a "pecking order". The largest, strongest rats get the best food, water and females. Rats do not pair off forever. A female rat may mate with several males and remain with one male as long as he can defend himself.

Why do rats chew so much?

The upper incisors (large top teeth) grow 4 1/2 inches per year. The bottom incisors grow 5 3/4 inches per year. Rats gnaw on wood and other objects just to keep their teeth from growing too long. They also use their teeth to chew through the corner of a door to gain access into a structure.

Can rats swim?

Norway rats are capable of running up to 1/2 mile. They can swim continuously for 60 to 72 hours before drowning. Once inside a broken sewer pipe, they can swim up through a toilet bowl.

How high can a rat jump?

Although Norway rats are usually burrowing animals and live under the ground, they are good climbers and runners. They can do a standing high jump of almost 2 feet and a running jump of 3 feet.

Do rats have good eyesight?

Rats are color-blind. In addition, they have relatively poor vision and rely on their oral vibrissae (whiskers) for help in movement. Therefore, once inside a structure, rats like to stay close to walls. This should be kept in mind when placing rodent baits.

How far do rats travel?

In the fall of the year, rats will travel up to 5 to 6 miles to reach new quarters and protection for the winter. Usually, the Norway rat will enter the closest structure that is accessible. Once near a food source, the rat will remain in that area. Rats are carried across the country in trucks, trains and cars. They are transported across oceans in ships.

Are Norway rats a problem?

It is estimated that the amount of food that rats destroy in the United States would feed all of Europe.

Do rats carry disease?

Rats are associated with approximately 55 different diseases. (See Public Health Service Sheet on rodent-borne diseases, p.6)

What type of droppings do Norway rats leave?

Norway rat droppings are black, solid and about three times as long as wide. They are 1/2 to 3/4 inches long, blunt at both ends. Sometimes, 2 or 3 droppings will be stuck together in a chain. Fresh droppings will be soft, old droppings will be hard.

What are the major chemicals used to kill rats?

For a summary of the major rodenticides used today, review the National Pest Control Association rodenticide summary sheet located on page 8. There are two major kinds of rodenticides: one-shot poisons called quick killers which require only one feeding for rodent death, and anti-coagulant poisons which require several (3 to 5) feedings for rodent kill.

What are the advantages of an anti-coagulant bait?

Anti-coagulants baits have several advantages:

1) They are relatively safe for humans and pets, in that several feedings are required for death.
2) There is an antidote in case of accidental poisoning (Vitamin K).
3) The rodent dies slowly, therefore dehydrating (losing water) before it dies. When death occurs, there is less time needed for decay. This reduces the number of cases and length of time that bad odor lingers in a structure.
4) Good for killing both mice and rats.
5) Acceptable poison baits can readily be made.

6) Secondary kill of other animals by eating the dead rats is not a problem.
7) High kill can be obtained.

The major disadvantages are that it takes several days to possibly weeks to see results and pre-baiting may be necessary.

Will rats eat poison or go near a trap touched by human hands?

Rats live near man and eat his food and garbage. They are, therefore, used to the smell of humans and not scared away by human odors. Rats often refuse to eat baits because the baits are not fresh and appetizing.

How do you determine if rats are present?

When rats are present, they usually produce one or more of the following signs: leave fecal pellets, have smooth runways, leave grease marks on walls and/or gnaw holes. Inspection with a black light will show rodent urine which fluoresces. It is also important to determine the extent of the infestation. Ask the people living in the building if they ever see rats. Be careful, some people like to exaggerate.

What are the basic principles of successful rodent control?

Steps in rodent control include:

1) Inspect and locate where and how the rats enter, live and feed, and roughly how great an infestation exists.

2) If possible, eliminate rodent food, water and shelter areas.

3) If possible, s[illegible]hat the structure is rodent proofed.

4) Kill the rats following the recommendations on the control sheet.

5) Control of fleas and mites may have to accompany rodent control.

How do rats contaminate?

In addition to eating food and defecating on the food that remains uneaten, rats continually urinate because they have no urinary bladder. Rats also shed hair twice during their lifetime. The rat has about one-half million hairs on his body.

RODENT-BORNE DISEASES

(A Public Health Service Sheet)

Public health workers of today do not experience the great outbreaks of plague which once brought suffering and death to millions of humans. Only rarely do they encounter *murine typhus* which was once widespread in the southern United States. Yet, rodent-borne diseases are with us still -- in our finest homes, apartments, ships, trains, and aircraft, as well as in our slums: *plague, murine typhus, rickettsialpox, rat-bite fever tetanus, leptospirosis, lymphocytic chorlomeningitis, and listeriosis.* In addition, rodents attack our stored food (300 million dollars worth annually), devouring some, contaminating and spoiling much more. Their constantly growing teeth gnaw and gnaw, damaging property and starting fires.

SALMONELLOSIS, bacterial food poisoning, can be initiated by rodent feces deposited on suitable foods. This is probably the commonest disease transmitted by domestic rodents in the United States at the present time.

PLAGUE, a highly fatal bacterial disease of mammals caused by *Pasturella Pestis*, is transmitted from field rodent to field rodent by the bites of infected fleas. When the rodent disease-rate is high, *plague* may spill over into domestic rodents and thence to man. In heavily infected areas, occasional transmission may occur directly from field rodents to man.

MURINE TYPHUS, a rickettsial disease of rodents (especially rats) caused by *Rickettsia Typhi*, is transmitted from rodent to rodent and to man by scratching infected flea feces into the skin. Occasional human cases occur when the domestic rat population is maintaining the disease at a moderately high rate.

LEPTOSPIROSIS, (Well's Disease) an acute systemic spirochetal disease of rodents caused by *Leptospira Icterohaemorrhagiae*, is transmitted from rodent to rodent and to man by contact with infected urine. Cases occur in humans handling rodents or working in a wet environment: soldiers in combat, fish handlers, children playing in contaminated water.

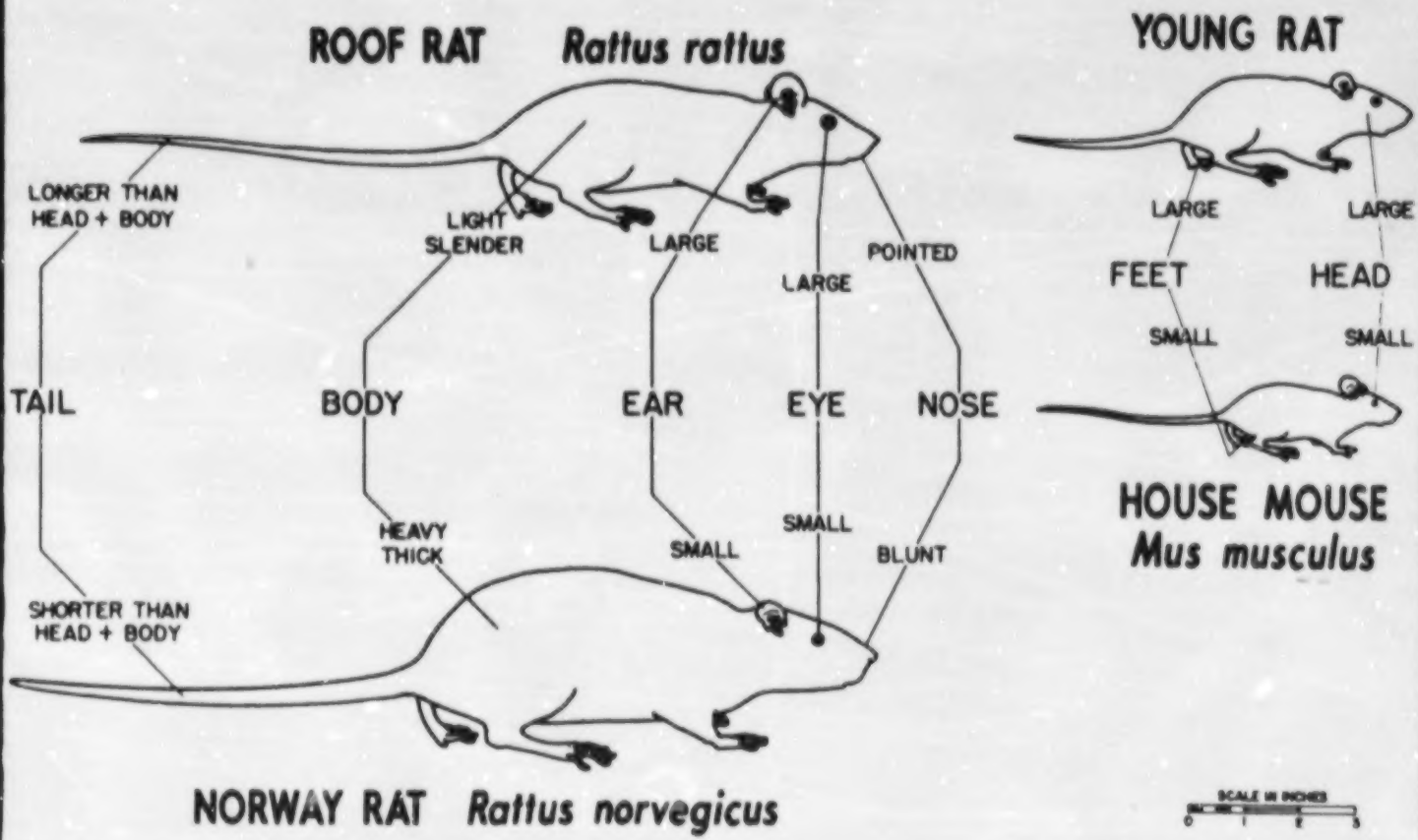
RAT BITE is common in areas where domestic rodent populations are high. Danger of *secondary infection* and *tetanus* should be minimized by proper disinfection and treatment. *Rat-Bite Fever*, a bacterial disease of rodents caused by *Streptobacillus Moniliformis*, is transmitted from rat to rat and to man by biting.

RICKETTSIALPOX, a febrile disease exhibiting a chicken-pox type rash, is caused by *Rickettsia Akari* and transmitted from house mouse to house mouse by the bite of the house-mouse mite (*Ailodermanyssus Sanguineus*). When mouse and mite populations are high, the disease may be carried into the human population in epidemic proportions.

LYMPHOCYTIC CHORLOMENINGITIS, a virus infection of house mice, may occur in man with a marked variation in clinical symptoms. Transmission from mouse to mouse and to man is by means of food or dust contaminated with respiratory droplets or powdered feces of infected animals.

LISTERIOSIS is a bacterial disease of rodents, ruminants, fowl and man caused by *Listeria Menocytogenes*. Transmission can probably occur from infected rodents to man via food and air contaminated with powdered rodent feces, although the epidemology of the disease is still relatively unknown.

FIELD IDENTIFICATION OF DOMESTIC RODENTS



CHARACTERISTICS OF COMMON RODENTICIDES

POISON	Percent in Bait	Effectiveness	Acceptance	Reacceptance	Tolerance Developed	Hazard to Humans	Antidote
Anticoagulants Warfarin, Pival, etc.	0.025	Good	Good	Good	No	Slight	Vitamin K and whole blood. Call a physician.
Red Squill (fortified)	10	Fair	Fair	Poor	No	Slight	Acts as its own emetic.
Zinc phosphide	1	Good	Good	Good	No	Moderate	Copper sulfate before emetic; cathartic and water; avoid fats and oils.
Arsenic trioxide	3	Fair	Fair	Fair	Yes	Moderate	Milk of magnesia, milk and water.
ANTU	3	Good	Good	Poor	Yes[a)]	Moderate	None
Sodium Fluoroacetate (Compound 1080)	½ oz. per gal.	Good	Good	Good	No	Extreme	None[b)]
Thallium sulphate	0.7	Good	Good	Good	No	Extreme[c)]	None reliable; sodium iodide and sodium thiosulphate recommended.
Strychnine (alkaloid)	0.6	Fair	Fair	Poor	Yes	Moderate	No emetic after 10 minutes; charcoal in water and sedative; keep in dark room.
Strychnine (sulfate)	0.8	Fair	Fair	Poor	Yes	Moderate	

*Effective against Norway rats. **Effective against Norway and roof rats. ***Effective against mice only.

NOTE: The anticoagulants sodium fluoroacetate, zinc phosphide, and thallium sulphate are effective against rats & mice.

a) After first exposure to ANTU, do not use again for at least 6 months.

b) Monoacetin or ethyl alcohol and acetic acid recommended.

c) Can be absorbed through unbroken skin. Chronic poisoning possible with absence of warning.

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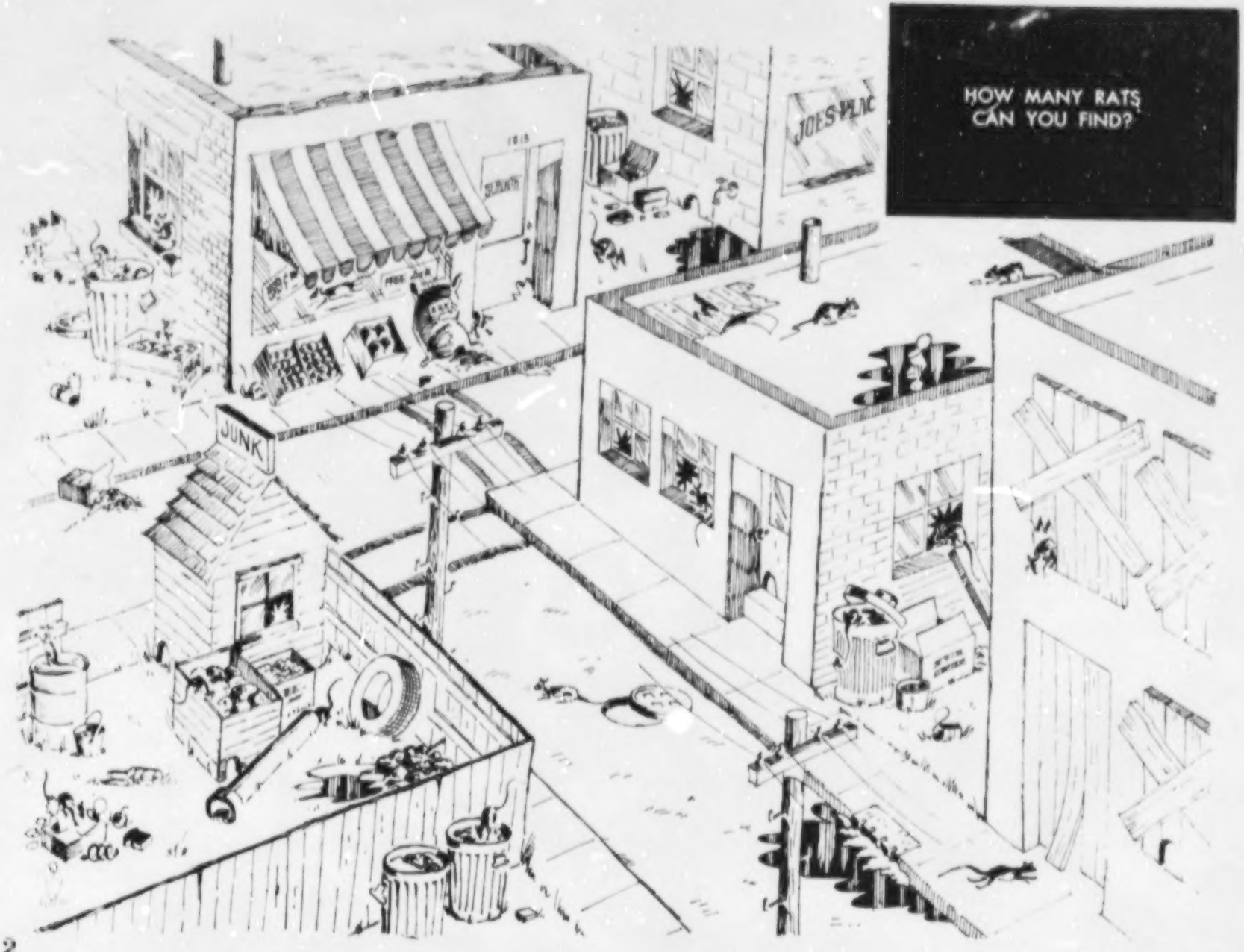
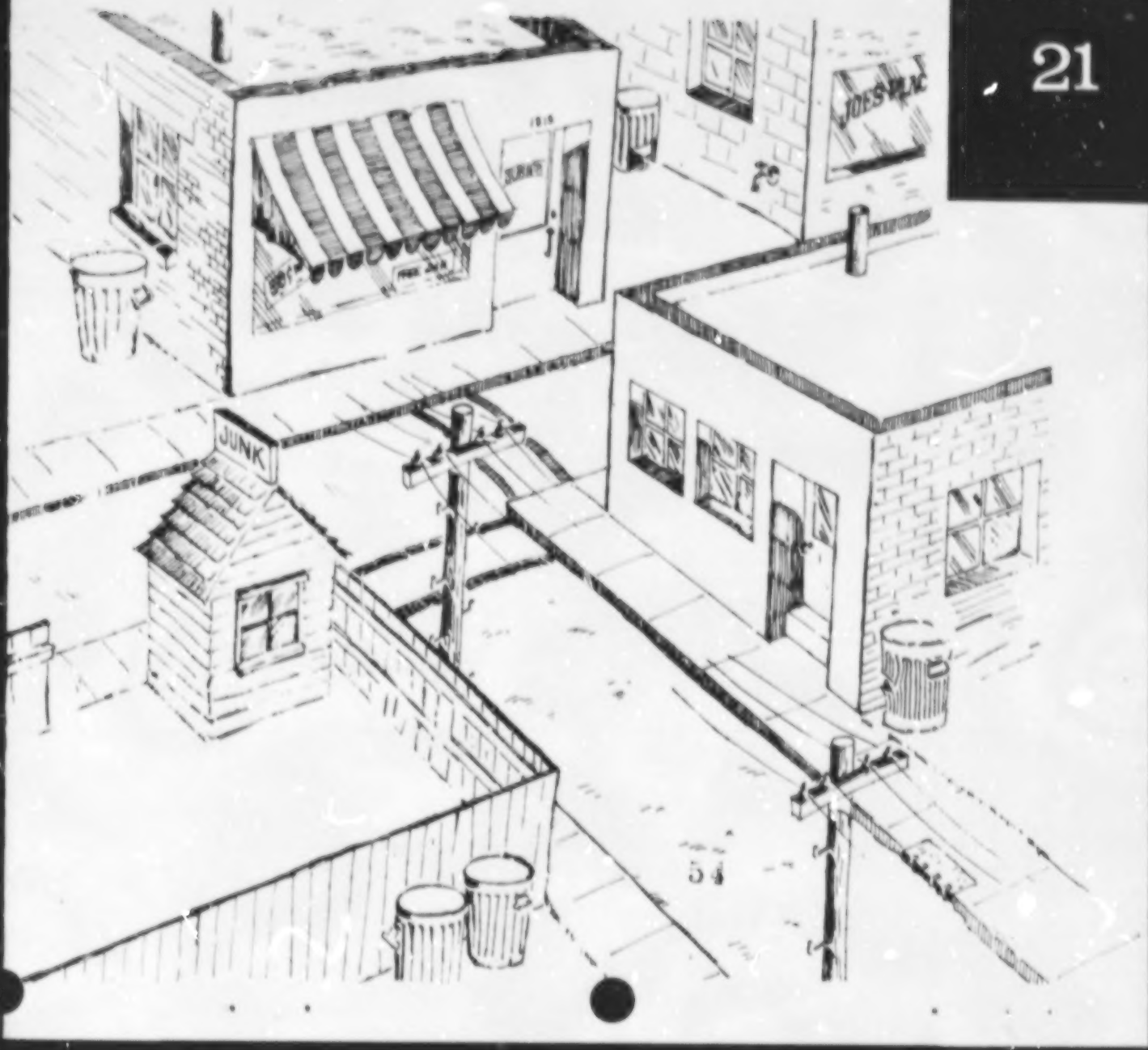
From: CDC Control of Domestic Rats and Mice. U. S. Department of Health, Education & Welfare.


HOW MANY RATS
CAN YOU FIND?
JOE'S PLACE
JUNK


JUNK
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II. SUGGESTED CLASS PROJECTS

A. Invitation to Person Involved in On-Going Project

Invite a person who has been involved in a rat-control project to speak to the class. If possible, get the individual who was responsible for designing the project, organizing the work and preparing the budget. The teacher should ask him to speak on his work and to specifically describe the area in which the project took place, including his estimate of the size of the rat population. Students may wish to ask questions concerning his exact plan of action, the budget requested including the breakdown of costs and other resources, variations needed from his original plans as the program progressed, to what extent the residents of the area were involved, what additional people were needed, and how the project worked out. Ask about the failures and successes, and finally, find out the future plans or projects for continuing control of the rats.

B. Schedule a Field Trip

If an outside speaker is not available, a field trip to an area where a rat-eradication project has been carried out can be used to gather the same kind of information. In this case, arranging the field trip and contacts with persons involved should be undertaken by the teacher well in advance to ensure gathering as much information as possible with the least disruption of others in their work.

C. Organize Student Project

The class may wish to organize a group of students to take on a project of rat eradication in a nearby area. Make use of information from outside sources and from the *RATS* program. Be sure to enlist the aid of your teacher, the school administration, your parents, local authorities and, of greatest importance, the residents of the area in which you wish to conduct your project.

III. FURTHER INSTRUCTIONAL USES OF *RATS*

A. As with most simulation programs, a good supplementary exercise for students is to carefully examine the model which underlies the program and determine some changes or extensions which could be made. Comparisons can be made between results obtained with the present model and those obtained with the new model.

B. The advanced student with a knowledge of computer programming could develop a more sophisticated model allowing the entry of an entire plan of action for rat control with the ability to even input changes in the garbage level to correspond with logical clean-up rates depending on the resources available. The model could also be enhanced by inserting a cost factor for the various factors of poison type and level and clean-up rate.

IV. DESCRIPTION OF THE MODEL WHICH UNDERLIES *RATS*

Assumptions

1) All assumptions refer to one species of rat -- *RATTUS NORVEGICUS* -- the Norway rat.

2) Rats live 6 months unless affected by outside conditions.

3) The average number of rats per litter is 8.

4) The range of rats per litter is 2 to 22. The greater the amount of food available per rat, the greater the number of rats per litter.

5) The gestation period is 1 month.

6) Rats are sexually mature when they are 3 months old.

7) The ratio of males to females is 1:1.

8) Excess Rodents - when the population exceeds the carrying capacity, the excess rats are subject to one of two conditions: they emigrate out of the area, or die by fighting and starvation. The model assumes 50% of the excess rats die and 50% emigrate.

a) Emigration factor of rats:

i) Rats will not emigrate our of an area if the rodent population is at or below maximum capacity.

ii) The excess rodent population emigrates proportionally by age group, with an equal proportion of excess rats leaving from each age group. Of those rats leaving the area, it takes a total of two days for all of the excess rats to emigrate, 50% per day.

b) Procedure used to determine immigration rate when working in a city:

i) After checking the garbage level, i12% of "maximum" carrying capacity is calculated.

ii) The number of rats present on a given day is subtracted from the "maximum" number of rodents possible in the area. The difference is the maximum number of rats which can *enter* over 200 days. (This value must be equal to or less than S - 2 * 6E4 where S = the garbage level selected by the student.) If the student selects an S value of 2 or less, the difference must be less than 6E4.

iii) Once the number of rodents over a 200-day period is calculated, the daily rate at which they enter is calculated as follows:

- A random number is selected and multiplied by 0.005. It must be less than the number of rats which are lacking from the maximum population.

If the rat population goes to Ø, emigrating rats have 3 to 10 days (randomly selected) before the rodenticide starts to kill them.

c) Procedure used to determine immigration rate when working in an apartment house:

i) The maximum number that can enter within 1 week is computed based on the current garbage level and population present as in the city. There is no restriction on the amount of rats which can enter on any one day.

d) Death rate of excess rats - Rats will die when there are more rats than an area can hold. They die in proportion to their age, which is a reflection of their strength. For the model, excess rats die in the following proportions:

80% of all rats 1 month old or less

50% of all rats 2 months old

40% of all rats 3 months old

10% of all rats 4 months old

5% of all rats 5 months old

2½% of all rats 6 months old

Of those rats which die, it takes a total of 2 days to die, with 50% of the total dying per day.

e) If a student initializes the rat population, it cannot go more than 12% over the maximum carrying capacity.

9) Shortage of rodents -- when there are fewer rats present than an area can support, immigration occurs. Immigration factor of rats:

a) They are randomly selected as to age (3,4,5, or 6 months old).

b) There is no immigration of rats into the area if the rat population is equal to or greater than the maximum number of rats the area can continuously support at the existing garbage level.

10) Each rat needs a minimum of three ounces of food per day to survive and reproduce.

11) The maximum number of rats that can survive in an area is dependent upon the sanitation of the area. Sanitation includes the amount of food and harborage available to the rat.

12) The maximum number of rats that can be maintained is as follows:

CARRYING CAPACITY OF ENVIRONMENT

Garbage Level	Apartment House	City
0	0	0 0
1	20	100,000
2	40	200,000
3	60	300,000
4	80	400,000
5	100	500,000
6	120	600,000
7	140	700,000
8	160	800,000
9	180	900,000
10	200	One Million

13) Below the carrying capacity, the limiting factor suppressing an increase in a rodent population is the amount of food available. At maximum population levels, harborage (nesting sites) becomes the limiting factor.

14) When initially inputting a given number of rats, an equal proportion become 1, 2, 3, 4, 5, and 6 months old.

15) All rat poison used is 10 times more palatable than the food the rat normally eats. This takes into consideration that the rat bait is placed in easy access of the rats.

16) All rats die after one feeding of the quick-kill bait.

a) Quick-kill rodenticides will eliminate 60% of a rodent population within one day.

b) The quick-kill bait is never as efficient again for 6 months, at which time new rodents are present and the kill efficiency returns to 60%.

c) The day after rodents eat a quick-kill rodenticide, its efficiency drops to 0%. It increases proportionately per month (an increase of 10% of the current population) until it returns to its original 60% maximum efficiency, providing it is not used for 6 months. Each time the quick-kill bait is used, it drops to 0% efficiency.

17) Anticoagulant rodenticides will eliminate 100% of a rodent population if no other food is available.

a) Each rat must ingest 3 to 10 consecutive feedings of anticoagulant bait before death occurs. Rodents eat once a day. The exact value between 3 and 10 selected is randomly picked by the computer to designate the number of consecutive feedings required to kill 1- and 2-month-old rats. Once this figure is selected, an additional day of feeding is then required to destroy 3- and 4-month-old rodents. 5- and 6-month olds require still another day of feeding before death occurs. Therefore, the older the rat, the more poison it requires to cause death.

b) If a rodent eats less anticoagulant bait than is necessary for kill, and switches to non-poisonous food, it will recover and refuse to eat the poison again. If forced to eat the poison, the effect is non-cumulative; therefore, the rodent must again eat 3 to 10 feedings before death will occur.

18) The number of rodents that eat a poison (quick-kill or anticoagulant) on any given day is dependent upon:

a) ratio of non-poisonous to poisonous food available.

b) number of rodents present.

c) type of poison used.

19) Every time a new but similar type poison is used, the old poison not eaten by the rodents remains in the area.

20) If all rodents leave or die so that the only rodents left are less than 1 month old, these young rats will die.

21) Rodent damage is calculated to be $5/rat for a 6-month period or 2.8¢/rat/day.

22) The contamination level is based on the average number of rodents present per month. The contamination level increases as the number of rodents increases. The contamination level varies from 1 to 10 and is directly proportional to the maximum number of rats present per garbage level.

23) The maximum amount of rat bait allowed is equal to 10 times the maximum carrying capacity of the area: for a city = 11.2 million pounds; for an apartment = 2240 pounds. If you input more than the maximum amount of poison, you are told: "YOU ARE BURIED IN POISON...NOT VERY PRACTICAL."

24) The cost of rat poison is 44¢ per pound.

List of VARIABLES for *RATS*

VARIABLE	MEANING
A	Cumulative dollar damage due to rodents
B	Daily births/death temporary
B1	Cumulative births for report
B2	Cumulative births for run (total)
C	Month for report/contamination level
C1	Day for report
C2	Daily population status switch/printing temporary
D(6)	Death rates
D	Day counter
D8	Cumulative deaths for run (total)
E	Type of environment
E9	Excess population temporary
F	Food factor
G	Immigration temporary
H	Cumulative deaths for report
I	General purpose temporary
I1	Cumulative immigration for report
I2	Cumulative immigration for run (total)
J	Month counter
K	Poison over food strength
L	Garbage level temporary for immigration
M(6)	Daily mortalities
M	Immigration maximum over time

VARIABLE	MEANING
M6	Death due to age in 6-month old rats
M7	Cumulative emigration for report
M8	Cumulative emigration for run (total)
N	Cumulative poison cost
O	Excess population flag
P(6)	Population distribution by month
P	Poison type
P7	Number of pregnant rats
Q	Quantity of poison
R	Randomizer for immigration
R1	Randomizer for slow-kill poison
S	Garbage level
S1	Garbage level temporary
S2	Immigration -- sanitation timer
T	Quick-kill poison timer
T1	Slow-kill poison timer
U	Upper limit on poison-killing loop
V	Death temporary
W	Quick-kill effectiveness
X	Once-only report flag
Y	Total rat population
Z	Death temporary

V. REFERENCES

Bjornson, Bayard F., Harry D. Pratt and Kent S. Littig
CONTROL OF DOMESTIC RATS AND MICE
U. S. Public Health Service
Consumer Protection and Environmental Health Service
Environmental Control Administration
Rockville, Maryland (41 pages) 1969.

Brown, Robert Z.
BIOLOGICAL FACTORS IN DOMESTIC RODENT CONTROL
U. S. Public Health Service
Communicable Disease Center
Atlanta, Georgia (32 pages) 1960.

Dudderar, Glenn R. and John R. Beck
RATS AND THEIR CONTROL
Virginia Polytechnic Institute
Extension Division
Blacksburg, Virginia (Publication 272, 12 pages), 1969.

Frishman, Austin M.
REDI-REFERENCE CPSN 102
Copesan Services Inc.
1826 North Mayfair Road
Milwaukee, Wisconsin 53226 (pp.52.1-52.4), 1971.

National Pest Control Association
BIOLOGY AND HABITS OF COMMENSAL RODENTS
NPCA Technical Release 8-71
Elizabeth, New Jersey (1971).

Salvato, Joseph A. Jr.
CONTROL OF RATS AND MICE
New York State Department of Health
Albany, New York (22 pages), 1969.

UCOM Educational Inc.
RATS
UCOM Educational Inc.
Rochester, New York (14 pages), 1969.

VI. PROGRAM LISTING

```
100 REM RATS - A RAT POPULATION SIMULATION
105 REM DEVELOPED BY A. FRISHMAN, PROGRAMMED BY M. WEISNER
110 REM COPYRIGHT 1973, STATE UNIVERSITY OF NEW YORK
115 REM LATEST REVISION: 12-12-73
120 RANDOMIZE
125 DIMD(6),M(6),P(6)
130 READC9,X,D1,I2,M8,D8,B2,T1,D9,T,D,J
135 FORI=1TO6
140 READD(I)
145 NEXTI
150 PRINTTAB(12);"RATTUS NORVEGICUS POPULATION SIMULATION"
155 PRINT
160 PRINT
165 PRINT"WHICH ENVIRONMENT IS THE SIMULATION TO"
170 PRINT"BE CONDUCTED IN (1=APT HOUSE, 2=CITY)";
175 INPUTE
180 LETF=60
185 IFE=1THEN205
190 IFE<>2THEN165
195 LETF=F*5E3
200 PRINT
205 PRINT
210 PRINT"DO YOU WISH (1=YES, 0=NO) :"
215 PRINT
220 PRINTTAB(3);"AUTOMATIC INITIALIZATION OF POPULATION";
225 INPUTI
230 IFI=1THEN280
235 IFI<>0THEN220
240 PRINTTAB(8);"HOW MANY RATS ARE PRESENT";
245 INPUTP9
250 IFINT(P9)<>P9THEN240
255 IFP9<0THEN240
260 PRINT
265 IFP9<=11.2*F/3THEN280
270 PRINT"CHOOSE A SMALLER NUMBER OR AUTOMATIC INITIALIZATION."
275 GOTO220
280 GOSUB355
285 IFI=0THEN305
290 LETP9=S*F/3
295 PRINT"BASED ON A GARBAGE LEVEL OF";S;"IN ENVIRONMENT";E
300 PRINT"THE RAT POPULATION INITIALLY IS";P9
305 PRINT
```

```
310 GOSUB470
315 GOSUB560
320 FORI=1TO5
325 LETP(I)=INT(P9/6)
330 LETP8=P8+P(I)
335 NEXTI
340 LETP(6)=P9-P8
345 LETP8=0
350 GOTO1505
355 PRINT
360 PRINTTAB(8);"DAILY POPULATION STATUS";
365 INPUTC9
370 IFC8*(C8-1)<>0THEN355
375 PRINT
380 PRINT"MONTH, DAY FOR REPORT";
385 INPUTC,C1
390 IFC<JTHEN380
395 IFC>JTHEN410
400 IFC*C1=1THEN410
405 IFC1<=DTHEN380
410 IFINT(C)<>CTHEN380
415 IFABS(C1-15)>15THEN380
420 IFINT(C1)<>C1THEN380
425 PRINT
430 LETS1=S
435 PRINT"GARBAGE LEVEL UNTIL";C;"/";C1;
440 INPUTS
445 IFABS(S-5)>5THEN435
450 IFINT(S)<>STHEN435
455 IFS1=STHEN465
460 LETS9=7
465 RETURN
470 PRINT"TYPE OF POISON (0=NONE,1=QUICK KILL,2=SLOW (ILL)";
475 INPUTP
480 LETI=0
485 LETQ9=0
490 IFP=0THEN540
495 IFP=1THEN505
500 IFP<>2THEN470
505 PRINT"QUANTITY OF #";P;"POISON (LBS)";
510 INPUTQ9
515 IFQ9*I<=112*F/3THEN530
520 PRINT"YOU ARE BURIED IN POISON.......NOT VERY PRACTICAL."
525 GOTO505
530 IFQ9<0THEN505
535 LETC9=C9+.44*Q9
540 RESTORE
545 PRINT
550 READM7,I1,B1,P8
555 RETURN
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```
560 IFC2=0THEN580
565 PRINT
570 PRINT"DAY","RATS"
575 PRINT"---","----"
580 RETURN
585 REM DAILY UPDATE
590 LETM9=0
595 LETD1=D1+.398*P9
600 IFP9>0THEN615
605 LETT=180
610 LETT1=0
615 LETM1=1
620 IFD=1THEN630
625 IF.3*P(6)>=M6THEN635
630 LETM6=INT(P(6)/(31-D)+.75)
635 LETM(6)=M6
640 LETF=INT(P9-09-5*F/3)
645 IFF>0THEN665
650 LETF9=0
655 GOTO705
660 REM EXCESS POP
665 LETD9=1-D9
670 IFD9<>1THEN690
675 LETF9=INT(F/4)
680 IFF9>0THEN690
685 LETF9=2
690 LETM9=2*(P9-INT((M(1)+M(2)+M(3)+M(4)+M(5)+M(6))/9))
695 IFM9>=0THEN705
700 LETM9=0
705 IFP=0THEN800
710 REM POISON
715 IFQ9=0THEN805
720 LETK=09*10/((F*5)/16+09*10)
725 IFP=0THEN820
730 REM O-K POISON
735 LETW=0
740 IFT<=30THEN760
745 LETW=.1*T/30
750 IFW<=.6THEN760
755 LETW=.6
760 LETW=W*K
765 LETT=0
770 LETU=6
775 FORI=1TOU
780 LETM(I)=M(I)+INT(W*P(I)+.5)
785 IFM(I)<=P(I)THEN795
790 LETM(I)=P(I)
795 NEXTI
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800 LETC9=C9-W*P9*3/16
805 IFC9>0THEN825
810 LETC9=0
815 GOTO825
820 REM S-K POISON
825 IFT1<>0THEN850
830 LETR1=INT(10*RND(R1)-3)
835 IFABS(R1-2)>2THEN830
840 LETR1=R1+3
845 LETU=0
850 LETW=K
855 LETT1=T1+1
860 IFT1<R1THEN800
865 LETR1=R1+1
870 LETU=U+2
875 IFU<>8THEN775
880 LETU=6
885 GOTO775
890 LETP9=0
895 REM BIRTH
900 IFP9-P(I)<>0THEN910
905 LETM(I)=P(I)
910 FORI=1TO6
915 LETP8=P8+M(I)
920 NEXTI
925 LETP7=INT((P(4)+P(5)+P(6))/2+.5)
930 LETI=S-P9/(F/3)
935 IFABS(I)<=3THEN945
940 LETI=SGN(I)*3
945 LETB=INT(P7*(I+3)*11/99+.5)
950 LETB1=B1+B
955 LETP(I)=P(I)+B
960 REM DEATH
965 LETD=M9
970 FORI=1TO6
975 LETZ=INT(D(I)*P(I)+.5)
980 IFZ>=1THEN990
985 LETZ=1
990 IFM9>ZTHEN1000
995 LETZ=M9
1000 LETM9=M9-Z
1005 IFP(I)-Z-M(I)>=0THEN1035
1010 IFI<>6THEN1000
1015 LETM9=M9-M6
1020 LETM9=M9+Z+M(I)-P(I)
1025 LETP(I)=0
1030 GOTO1040
1035 LETP(I)=P(I)-M(I)-Z
1040 NEXTI
1045 IFM1<>1THEN1065
1050 FORI=1TO6
```

```
1055 LETM(I)=0
1060 NEXTI
1065 LETP9=P(1)+P(2)+P(3)+P(4)+P(5)+P(6)
1070 LETM1=0
1075 IFP9=0THEN1085
1080 IFM9<>0THEN970
1085 LETM7=M7+INT((P-M9)/2+.5)
1090 LETP8=P8+INT((P-M9)/2)
1095 REM IMMIGRATION
1100 IFS=0THEN1200
1105 IFS2/7<>INT(S2/7)THEN1145
1110 LETM=INT((S*22.4-P9)/20+.5)
1115 IFF=60THEN1150
1120 LETM=INT(S*6E4+.5-P9)
1125 LETS3=S-2
1130 IFS3>0THEN1140
1135 LETS3=1
1140 IFM<=S3*6E4THEN1150
1145 LETM=S3*6E4
1150 IFM>=0THEN1160
1155 LETM=0
1160 IFF>=60THEN1200
1165 IFM=0THEN1200
1170 LETM1=INT(RND(M1)*M+.5)
1175 IFF=60THEN1185
1180 IFM1>INT(M*.005+.5)THEN1170
1185 IFM-M1<0THEN1170
1190 LETR=INT(10*RND(R)+.5)
1195 IFABS(R-1.5)>1.5THEN1190
1200 LETM=M-M1
1205 LETI1=I1+M1
1210 LETP(3+R)=P(3+R)+M1
1215 LETP9=P9+M1
1220 LETS2=S2+1
1225 IFC2=0THEN1235
1230 PRINTD,P9
1235 IFC1<>DTHEN1463
1240 IFC<>JTHEN1460
1245 PRINT
1250 PRINT"REPORT ON";J;"/";D";"
1255 PRINT"TOTAL POPULATION=";P9
1260 IFP9=0THEN1395
1265 FORI=1TO6
1270 LETC=C+1
1275 IF(I-1)/3<>INT((I-1)/3)THEN1290
1280 PRINT
1285 LETC=0
1290 PRINTTAB(C*20);"P(";I;")=";P(I);
1295 NEXTI
```

```
1300 PRINT
1305 GOSUB1535
1310 PRINT
1315 PRINT"DO YOU WISH TO CONTINUE THIS RUN";
1320 INPUTI
1325 IFI=0THEN1590
1330 IFI<>1THEN1315
1335 GOSUB355
1340 PRINT
1345 IFP=0THEN1360
1350 LETQ9=INT(Q9*100+.5)/100
1355 PRINT"CURRENT POISON TYPE:";P;"    QUANTITY LEFT=";Q9
1360 PRINT"TYPE OF POISON (0=NONE,1=OK,2=SK";
1365 IFP*Q9=0THEN1375
1370 PRINT",3=LEAVE CURRENT POISON";
1375 PRINT")";
1380 INPUTI
1385 IFI*(I-1)*(I-2)*(I-3)<>0THEN1360
1390 IFI=3THEN1445
1395 IFP=ITHEN1420
1400 IFI*P*Q9=0THEN1415
1405 PRINT"POISON TYPE";P;"WILL BE REMOVED WHEN NEW POISON IS PU
1410 LETT1=0
1415 LETQ9=0
1420 LETP=I
1425 LETI=Q9
1430 GOSUB490
1435 LETQ9=Q9+I
1440 GOTO1455
1445 IFP*Q9=0THEN1360
1450 GOSUB540
1455 GOSUB560
1460 LETD=D+1
1465 LETT=T+1
1470 IFD<=30THEN585
1475 LETPR=PR+D(3)
1480 FORI=6TO2STEP-1
1485 LETP(I)=P(I-1)
1490 NEXTI
1495 LETP(1)=0
1500 LETJ=J+1
1505 LETD=1
1510 PRINT
1515 PRINTAB(12);"***** MONTH";J;"*****"
1520 PRINTAB(12);"TOTAL POP.=";P9
1525 PRINT
1530 GOTO585
```

```
1535 PRINT
1540 PRINT"BIRTHS=";B1;TAB(30);"DEATHS=";DR
1545 PRINT"EMIGRATION=";M7;TAB(30);"IMMIGRATION=";I1
1550 LETX=X+1
1555 LETMR=MR+M7
1560 LETI2=I2+I1
1565 LETB2=B2+B1
1570 LETDR=DR+DR
1575 RETURN
1580 DATA0,0,0,0,0,0,0,0,0,180,1,1
1585 DATA.8,.5,.4,.1,.05,.025
1590 PRINT
1595 PRINT
1600 PRINT"FOR THIS RUN:"
1605 IFX=1THEN1635
1610 LETM7=MR
1615 LETDR=DR
1620 LETI1=I2
1625 LETB1=B2
1630 GOSUB1535
1635 IFP=0THEN1650
1640 LETC3=INT(100*C3+.5)/100
1645 PRINTTAB(8);"QUANTITY OF UNUSED POISON TYPE";P;"IS";C3
1650 IFC3=0THEN1660
1655 PRINTTAB(3);"COST OF POISON IS";INT(C3*100+.5)/100;"DOLLARS"
1660 PRINTTAB(7);INT(D1*100+.5)/100;"DOLLARS OF DAMAGE DUE TO RATS"
1665 PRINTTAB(8);"PRODUCING A CONTAMINATION LEVEL OF";
1670 LETC=0
1675 IFD1=0THEN1695
1680 LETC=INT(1.5+(D1/.028)/(J*30+D)/(F/3))
1685 IFC<11THEN1695
1690 LETC=10
1695 PRINTC
1700 END
```

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